Description

Apparatus for data transmission path detection

5   The present invention relates to an apparatus for data transmission path detection and to a method for finger positioning in a rake receiver, and relates in particular to an apparatus for receiving a data stream which can be transmitted via at least one data
10   transmission path, with data transmission paths being set on the basis of a finger positioning signal.

CDMA data transmission systems, for example for use in a 3GPP-WCDMA-FDD device, usually have a "rake" receiver
15   comprising various "fingers", with each finger being assigned to a delayed path (data transmission path) [lacuna] received signal.

The number of active fingers and the delay in each
20   "finger" in a rake receiver are assigned on the basis of a data transmission path searching unit. The operating parameters for the data transmission path searching unit are assigned by a "finger" management unit.
25
In wireless data stream transmission systems, signals pass via different data transmission paths to which different "fading" can be applied.

30   Since every data transmission path has a different length and the data stream signals propagate on the different paths at approximately the same data transmission speed, the data stream signal arrival times at the data stream receiver differ, in some cases
35   substantially, for the different data transmission paths.

The data transmission path searching unit is now used to determine an arrival time for the data stream

signals from the different data transmission paths. In line with the 3GPP standard (UMTS), the data stream is made up of frames and slots (data frames and data slots). A data frame has, by way of example, a duration of 10 milliseconds (ms) and contains 15 data slots. Each data slot has 2560 chips, which means that the chip frequency in this example is 3.84 MHz.

Since the bandwidth of a CDMA system is usually high, a chip period is very small, which means that delays on different data transmission paths are usually greater than one chip period.

These delayed arrival times for the various propagation paths result in data symbols transmitted at various times being superimposed at the receiver, an effect which is called intersymbol interference (ISI) and, without suitable countermeasures, has disadvantageous consequences for data reception. To compensate for ISI and to make advantageous use of the diversity of the various propagation paths, CDMA systems usually involve the use of a technique which is used to receive the data stream signals from all the relevant data transmission paths separately, and they are then combined.

On the basis of the prior art, this is done in a rake receiver, which is a data stream receiver which receives as many multipath data stream signals as possible. The rake receiver combines the signals from all these paths to produce a data stream signal which is as "interference free" as possible and which is stronger than the individual components. Individual paths are found by cross-correlating a reference pattern with the received signal.

The estimation of "power delay profiles" (PDPs) is fundamental to the operability of a rake receiver. The

power delay profiles for different data transmission paths are estimated, by way of example, by a mobile UMTS receiver in order to determine the amplitude or a power and the delayed timing of the data transmission

5   paths for data streams with regard to a receiver timing reference.

The power delay profile is determined by means of a correlation using a (primary or secondary) "pilot

10   channel" (CPICH - Common Pilot Channel) which transmits a predetermined symbol sequence. In conventional manner, a complex correlation is provided between the incoming signal (r(i)), which is sampled at double the chip rate, and a known, complex conjugate pilot

15   sequence signal p*(i), likewise sampled at double the chip frequency, in line with the general relationship, where N_{corr} is the correlation length.

$$\underline{corr}_{compl}(n) = \frac{1}{N_{corr}} \sum_{i=0}^{N_{corr}-1} \underline{r}(2i+n) \cdot \underline{p}*(2i) \quad n = 0,1,2,...,L-1 \qquad 20$$

In the case of the transmission diversity which is

20   possible in the UMTS standard, it is necessary to perform this correlation for the data transmission paths of an "antenna 1" and of an "antenna 2". In this context, the expressions "antenna 1" and "antenna 2" denote two different transmission devices in a data

25   stream transmitter, for example antennas, so that at least two different data transmission paths are produced. In this context, the correlation length N_{corr} is an even-numbered multiple of a pilot sequence symbol length, i.e. an even-numbered multiple of a CPICH

30   symbol length of 256 chips. Although increasing the correlation length N_{corr} increases the signal-to-noise ratio for a power delay profile estimation in a desirable manner, on the other hand this power delay profile estimation then becomes more sensitive to any

sampling clock error. For this reason, a power delay profile estimation needs to be averaged over time.

5   The operability of the rake receiver is based quite fundamentally on correct positioning of a particular number of rake fingers on multiple data transmission paths in order to be able to combine the power thereof and to obtain a diversity boost.

10   Conventional methods use a "PDP (Power Delay Profile) determination device" in order to determine those data transmission paths which have the highest power. The output of each PDP determination device is compared with a threshold value, and all peak values in the

15   received signal above this threshold are processed further by a finger positioning block.

    Disadvantageously, the setting of a threshold value is extremely critical with regard to the detection of

20   incorrect data transmission paths. Particularly in environments with a low signal-to-noise ratio or a high level of noise, which can be brought about, in particular, by a moving, mobile data stream receiver on account of fading effects, the amplitude distributions

25   of noise and amplitude distributions of data transmission paths can overlap such that exact setting of a threshold value is no longer possible.

    In conventional manner, the PDP determination device is

30   in the form of a correlation filter, for example, which has the further disadvantage that secondary maxima are produced which simulate invalid data transmission paths, i.e. shadow data transmission paths.

35   If the threshold value is set to be too low, then a power delay profile determination is severely disturbed by noise, and not all peak values which are linked to a correlation of received signal and pilot sequence

signal correspond to actual, i.e. valid, data transmission paths.

Disadvantageously, the peak values of the useful signal and of the noise signal are subject to statistical processes, which means that a relation between data transmission paths and noise peak values in the case of power delay profile determination is a statistical process which is dependent on an existing noise scenario.

In particular, conventional methods have disadvantages to the effect that data transmission paths are not correctly identified if, as is unavoidable in the case of mobile systems, new data transmission paths appear and existing data transmission paths disappear, which means that uniform monitoring of the data transmission paths is necessary.

It is therefore an object of the present invention to provide an apparatus for receiving a data stream which can be transmitted via at least one data transmission path in which a level of accuracy for data transmission path detection is improved as compared with conventional methods, with noise peak values differing from data transmission path peak values, and shadow data transmission paths being able to be avoided.

The invention achieves this object by means of an apparatus having the features of patent claim 1.

In addition, the object is achieved by a method as specified in patent claim 9.

Further refinements of the invention can be found in the subclaims.

A fundamental concept of the invention is to perform data transmission path detection based on a three-stage threshold value setting method, with a peak value detection device and a data transmission path profile determination device interacting such that peak values are determined on the basis of a threshold value which can be adapted to the noise environment and, in a further stage, a filtering device is used to suppress secondary maxima brought about by the correlation filter in order to avoid shadow data transmission paths.

The advantage of the invention is thus that different signal-to-noise scenarios can exist with which the inventive apparatus can align itself.

Expediently, this increases the detection probability for valid data transmission paths, whereas a probability of detection of invalid data transmission paths is reduced as compared with methods based on the prior art.

Another advantage is that the setting of a threshold value is no longer critical as compared with the prior art, since the threshold value is automatically aligned with a noise environment.

It is also advantageous that different threshold values are provided which permit peak value detection, data transmission path profile determination and shadow data transmission path filtering.

In particular, it is expedient that the threshold values can be adapted to different environment scenarios if information is available about the environment scenarios.

Advantageously, the inventive apparatus can be implemented in a CDMA modem.

The inventive apparatus for receiving a data stream which can be transmitted via at least one data transmission path essentially has:
a) a data stream receiver for receiving the data stream;
b) a power delay profile determination unit for determining at least one power delay profile;
c) a peak value detection device for detecting at least one peak value in the power delay profile;
d) a data transmission path profile determination device for determining a data transmission path profile for the at least one data transmission path;
e) a filtering device for suppressing shadow path signals and for outputting a finger positioning signal; and
f) a setting device for setting data transmission paths, which are associated with a data transmission, on the basis of the finger positioning signal.

The subclaims contain advantageous developments and improvements of the respective subject matter of the invention.

In line with one preferred development of the present invention, the peak value detection device has a comparison unit for comparing the power delay profile with a first threshold value.

In line with another preferred development of the present invention, a power delay profile determination unit for determining at least one power delay profile for the at least one data transmission path is provided.

In line with yet another preferred development of the present invention, a summation unit for summing the data streams transmitted by individual data transmission paths is provided.

In line with yet another preferred development of the present invention, the peak value detection device has a threshold value setting unit which can be used to set the first threshold value adaptively.

In line with yet another preferred development of the present invention, the data transmission path profile determination device has a data transmission path profile unit for summing weighted peak values and a data transmission path detection unit for detecting a valid data transmission path.

In line with yet another preferred development of the present invention, the power delay profile determination unit is provided together with a peak value sorting unit in a common matched hardware block.

In line with yet another preferred development of the present invention, a received signal strength determination unit for determining the received signal strength of the received signal is provided in a matched hardware block.

The inventive method for receiving a data stream transmitted via at least one data transmission path also has the following steps:

a) the data stream is received in a data stream receiver via at least one data transmission path;

b) at least one power delay profile is determined using a power delay profile determination unit;

c) at least one peak value in the determined power delay profile is detected using a peak value detection device;

d) a data transmission path profile for the at least one data transmission path is determined in a data transmission path profile determination device;

e) shadow transmission path signals are suppressed and a finger positioning signal is output by a filtering device; and

f) data transmission paths, which are assigned to a data transmission, are set on the basis of the finger positioning signal using a setting device.

The "shadow transmission path" to which reference is made in this context is a transmission path which is invalid, i.e. which does not contribute to data transmission of the data stream which is to be transmitted. A shadow transmission path can be simulated, by way of example, by secondary maxima from a correlation filter contained in a power delay profile determination unit.

In line with yet another preferred development of the present invention, a first threshold value is set on a variable basis in the peak value detection device.

Advantageously, the inventive method involves the first threshold value being set on the basis of a noise environment.

Another advantage is that the first threshold value is set on the basis of a mean value, a variance and/or a standard deviation for noise peak values.

In line with yet another preferred development of the present invention, the first threshold value is matched to a noise environment such that a preselection of possible data transmission path positions is advantageously provided.

In line with yet another preferred development of the present invention, the power delay profile estimation and the peak value detection are performed periodically by the peak value detection device.

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The present invention advantageously permits the power delay profile estimation and the peak value detection to be performed periodically by the peak value detection device at an interval of time which 10 corresponds to a data frame or to a multiple of data frames.

In line with yet another preferred development of the present invention, a prescribable number of preceding 15 periods in the data transmission path profile determination device is stored, with the detected peak values preferably being summed in the manner of an ongoing histogram. It is also expedient that the data transmission path profile determination device stores 20 the prescribable number of preceding periods and weights the detected peak values before summation with a received signal strength.

In line with yet another preferred development of the 25 present invention, the temporal summation points when the detected peak values are summed by the data transmission path profile determination device correspond to delay positions $k = 0, 1, ..., L-1$ of a correlation function.

30

In line with yet another preferred development of the present invention, those data transmission path positions which appear fewer than a predetermined number of times are set to 0.

35

In line with yet another preferred development of the present invention, a second threshold value is prescribed in the data transmission path profile

determination device, and the peak values summed in the manner of an ongoing histogram are compared with it.

In line with yet another preferred development of the present invention, the second threshold value is set on the basis of an existing noise or an existing noise environment or an existing noise scenario.

In line with yet another preferred development of the present invention, the second threshold value is provided on the basis of the first threshold value, which is multiplied by a constant factor.

In line with yet another preferred development of the present invention, secondary maxima from a correlation filter are compared with a third threshold value in the filtering device for suppressing shadow transmission path signals.

In line with yet another preferred development of the present invention, the first, second and/or third threshold values are updated periodically.

Exemplary embodiments of the invention are illustrated in the drawings and are explained in more detail in the description below. In the drawings:

figure 1   shows a schematic block diagram of a data transmission system having multiple data transmission paths;

figure 2   shows a schematic structure for a pilot channel which can be used to transmit a pilot sequence signal having a prescribed symbol sequence;

figure 3   shows a block diagram of a rake receiver with
             devices for data transmission path detection
             and finger positioning;

5   figure 4   shows a graph showing peak values for the
                  useful signal (data transmission signal) and
                  for noise signals in relation to a threshold
                  value which is set in order to determine
                  power delay profiles;

10

     figure 5   shows a block diagram of an exemplary
                  embodiment of the inventive method;

     figure 6   shows a preferred exemplary embodiment based
15   on the present invention;

     figure 7   shows another preferred exemplary embodiment
                  based on the present invention; and

20   figure 8   shows yet another preferred exemplary
                  embodiment based on the present invention.

     In the figures, identical reference symbols denote
     components or steps which are the same or have the same
25   function.

     Figure 1 shows a schematic block diagram of a data
     transmission system in which different data
     transmission paths 101, namely direct data transmission
30   paths 101a and indirect data transmission paths 101b,
     101c, contribute to transmission of data stream 102.

     There are a direct data transmission path 101a and data
     transmission paths which proceed through reflections on
35   buildings, elevations and other facilities etc., such
     as the data transmission paths 101b and 101c. In this
     context, a data stream transmitter 200 typically has
     one or two transmission devices (antennas) 201 and 202,

while a data stream receiver 100 has a reception device
109.

As can be seen from the block diagram in figure 1, the
propagation times on the data transmission paths 101a-
101c transmitting the data stream 102 are different. In
a "worst case", the delay time is typically 30 µs,
which corresponds to a distance difference of 9 km.
This "worst case" delay time has been specified by test
cases in the 3GPP standard. To calculate a power delay
profile, a number L of values which, for this "worst
case", has been set to L = 240 is required.

Figure 2 schematically shows the structure of a pilot
channel with a prescribed pilot sequence. As shown, a
data stream is made up of individual data frames 203a
...203i...203N. In the exemplary embodiment of the
invention, each data frame has a duration of T_f = 10 ms
(milliseconds). Each data frame is divided into
individual slots 204a...204i...204n.

In the exemplary embodiment of the invention, a data
frame is divided into n=15 slots. Each slot transmits
10 symbols, which are denoted by A and -A in figure 2.
The first symbols, indicated by the reference symbol
205 for a first antenna 1 or for a first transmission
device 201, and the second symbols, indicated by the
reference symbol 206 for a second antenna 2 or for a
second transmission device 202, for a specific slot
form a pilot sequence signal with a prescribable pilot
sequence.

A symbol is made up of 256 chips in the exemplary
embodiment, where a chip represents the smallest
digital unit. This means that a time slot T_{slot} comprises
2560 chips, and when two bits are provided per symbol -
for real and imaginary parts, i.e. (1+j) - 20 bits are
provided for each individual slot 204a-204n.

With the indicated duration of a data frame 203 and the prescribed number of 15 slots which each contain ten symbols or 2560 chips, a chip rate of 3.84 Mchip/s is
5   obtained. To form correlation functions, the data stream is now sampled at double the chip rate, i.e. at 7.68×10^6 sampling steps per second.

This makes it possible to determine a correlation
10 function with a resolution of half a chip. Advantageously, a correlation length N_{corr} is set to a multiple of the symbol length (x1, x2, x4 ...).

The variable L indicated in the equation above thus
15 denotes a maximum shift when forming the correlation functions, i.e. n proceeds from 0, 1, 2 ... L-1. If L is set equal to 240, the result is a delay time of 31.25 µs, which is also sufficient for the "worst case".
20

In line with the equation above, the result both for an antenna 1 and for an antenna 2, i.e. transmission devices 201 and 202, is different correlation functions as a function of n, with a total power delay profile
25 being determined by forming the sum of the squares of the magnitudes of the individual correlation functions.

This results in a power delay profile PDP as a function of n as follows
30

$$\underline{X}_{Ant1}(n) = \sum_{i=0}^{Ncorr-1} \underline{r}(n+2i) \cdot \underline{p}^{*}_{Ant1}(2i) \qquad (1)$$

$$\underline{X}_{Ant2}(n) = \sum_{i=0}^{Ncorr-1} \underline{r}(n+2i) \cdot \underline{p}^{*}_{Ant2}(2i) \qquad (2)$$

$$PDP(n) = |\underline{X}_{Ant1}(n)|^2 + |\underline{X}_{Ant2}(n)|^2 \qquad (3)$$

In equations (1) to (3), the received, complex signal (received signal) is respectively denoted by $\underline{r}(n)$, while $\underline{p}(i)$ denotes the complex pilot signal, where $r(n)$ and $p(i)$ are respectively sampled at double the chip
5   rate.

In this case, the shift is indicated by $n = 0, 1, 2,$ ... $L-1$.

10   The power delay profile PDP is thus obtained through the sum of the squares of the magnitudes in line with equation (3) and is denoted by PDP(n). The power delay profile determination now needs to be averaged over a plurality of blocks with a correlation length N_{corr}. N_{avg}
15   denotes a number of blocks over which averaging takes place, the magnitude N_{avg} being able to vary on the basis of the network conditions.

In line with the example of the invention, it is now
20   possible to alter the correlation length N_{corr} and the number of averaging operations N_{avg} without the need to alter or align hardware designs.

Figure 3 shows a rake receiver which is used as a data
25   stream receiver for receiving a data stream 102 which can be transmitted via at least one data transmission path. The rake receiver comprises a power delay profile determination unit 303 which is used to determine a power delay profile 300 (PDP).
30

The rake receiver also has a data transmission path detection unit 304, a setting device 305 and a processing device 308. The fundamental components of the processing device 308 comprise a summation unit 310
35   which sums different rake fingers 309a-309n in order to stipulate data transmission paths 101, 101a-101c which are suitable for transmitting the data stream 102.

The rake receiver receives the data transmitted using the data stream 102 in the form of a received signal 301.

5   The received signal is then correlated with a pilot sequence signal in the power delay profile determination unit, as already described, the correlation function for determining a power delay profile as a function of (k), i.e. the variable

10   $pdp_{est}(k)$, having the following form:

$$pdp_{est}(k) = \frac{1}{N_{avg}} \cdot \frac{1}{N^2_{corr}} \cdot \sum_{\ell=0}^{N_{avg}-1} \left| \sum_{n=n_{start}+\ell \cdot N_{corr}}^{n_{start}+(\ell+1)N_{corr}-1} r(2n+k) \cdot p^*(2n) \right|^2$$

where k = 0,1,...,L-1   (4),

the received signal 301 being denoted by r(n) and the

15   pilot sequence signal being denoted by p(k) in this context, with the two signals representing complex variables and being prescribed on the basis of the following equations (5) and (6):

20   $r(n) = r_s(n) + jr_Q(n)$ (5)

    $p(n) = p_s(n) + jp_Q(n)$ (6)

N_{corr} thus denotes a (partial) correlation length and N_{avg} denotes a number of averaging operations over (partial)

25   correlations.

Both signals, the received signal and the pilot sequence signal, are sampled at double the chip rate. The power delay profile pdp(k) determined in line with

30   the above equation (4) is finally output from the power delay profile determination unit 303 and is supplied to the data transmission path detection unit 304.

In line with the invention, a first threshold value

35   103a (explained below with reference to figure 4) is

now added at a low position in the power delay profile determination unit 303, which means that although data transmission paths have been preselected, a high rate of invalid data transmission paths is obtained.

5

In the data transmission path detection unit, the peak values 401a-401n (figure 4) of a received signal power 107 are summed, with values which belong to the same delay time (k) being added. In this context, it is possible to stipulate a number N_{occ} which indicates how often a peak value 401a-401n needs to have been above the settable first threshold value 103a in order for the position of this peak value to be identified as a data transmission path.

15

A corresponding data transmission path position signal 306 is then output from the data transmission path detection unit 304 and is supplied to the setting device 305. The setting device 305 then selects those positions from the power delay profile which need to be received with the fingers of the rake receiver.

A rake finger thus corresponds to a propagation path. The rake fingers are summed in the summation unit 310 of the processing device 308 in accordance with a finger position signal 307 which is output by the setting device 305 and are output as an output signal 311.

Figure 4 shows a graph with different peak values 401a-401n, which correspond to data transmission paths 101a-101n, and also noise peak values 402a-402n. In addition, the right-hand graph in figure 4 shows a function of a probability distribution 111 over a power 108, with two maxima having been set by way of example. The maximum at low power 108 corresponds to a noise signal 104, while the maximum at high signal power corresponds to the data transmission paths 101. The

distance between the two maxima can be referred to as a signal-to-noise ratio 105. In conventional methods based exclusively on the setting of the first threshold value 103a, one drawback is that if the threshold value
5 103a has been set to be too low, a false alarm rate rises inadmissibly, whereas if the threshold value 103a has been set to be too high, a detection rate for valid data transmission paths decreases.

10 In line with the invention, as will be explained below with reference to figure 5, the first threshold value 103a is set to be low, which means that numerous noise peak values 402a-402n are also detected.

15 Figure 5 shows a block diagram relating to the performance of a method in line with a preferred exemplary embodiment of the invention. Besides a peak value detection device 501, data analysis data processing is performed in a data transmission path
20 profile determination device 502 and in a filtering device 503.

The peak value detection device 501 is supplied with a power delay profile signal which is determined by the
25 power delay profile 300. This signal is compared with the set, first threshold value 103a in a comparison unit in the peak value detection device 501. This first threshold value 103a is chosen to be low in comparison with methods based on the prior art, as a result of
30 which a detection probability for invalid paths rises, but also a detection probability for valid paths increases overall. The value which is output from the peak value detection device 501 and is supplied to the data transmission path profile determination device 502
35 thus also represents just one preselection of possible data transmission path positions. In this first step, power delay profile determination (or power delay profile estimation) and peak value detection are

performed periodically, typically with an interval of time for the frame or multiple frames, i.e. at an interval of 10 ms, respectively 20 ms, ... etc.

5 The signal which is output by the peak value detection device 501 is processed further in the data transmission path profile determination device 502. In the data transmission path profile determination device, the detected peak values 401a-401n, like the

10 detected noise peak values 402a-402n, are added for the last M periods for respectively identical delays (k) in line with the method of an ongoing histogram. The containers for this ongoing "histogram" correspond to all possible delay positions k(0...L-1). All positions

15 which do not appear at least N_{occ} times within this observation window of length M are set to 0 in order to suppress high noise peak values or unstable data transmission paths.

20 Since the number of detected peak values is typically low as compared with the power delay profile length (N_{peak}<<L), this data transmission path profile histogram needs to be calculated only for the delay positions at which a path has appeared within the last M-PDP

25 determination periods.

The result of this histogram is subsequently compared with a second threshold value 103b. All positions which exceed this second threshold value 103b are processed

30 further and are output from the data transmission path profile determination device 502.

The second threshold value 103b is derived from an estimation of the noise environment. Since noise peak

35 values are statistically independent events, they usually appear at different positions in successive PDP determination steps. The second threshold value can be chosen, by way of example, on the basis of

$$S_{103b} = N_{occ} \cdot S_{103a} \qquad\qquad (7),$$

where S denotes the corresponding threshold values.

Equations (8) and (9) below thus give probabilities of noise peak values 401 being identified which are increased as compared with the conventional method, which uses just a peak value detection device 501. At the same time, the detection probability for valid data transmission paths (equation 9) has remained the same.

$$P_{502} = (P_{501})\, N_{occ} \text{ for } 402 \qquad\qquad (8)$$

$$P_{502} = P_{501} \qquad \text{for } 401 \qquad\qquad (9)$$

On account of this effect, most noise peak values are suppressed at the stage of the data transmission path profile determination device 502, while a detection probability for the peak value 401, 401a-401n for the useful data stream signal is maintained.

The output signal from the data transmission path profile determination device is finally also supplied to the filtering device 503, which provides a further improvement in the signal-to-noise ratio.

In the filtering device 503, a third threshold value 103c is provided which is used to suppress secondary maxima from a correlation filter device which is used in the power delay profile determination unit 303. The filtering device 503 is necessary particularly in scenarios in which a high signal-to-noise ratio is maintained, in which case the amplitudes of the correlation secondary lobes are in the same range or higher than the noise peak values.

These secondary maxima are brought about by less than optimal orthogonality in sampling code sequences of length N_{corr}, and typically have the same position in consecutive PDP determination steps, these being spaced

5 apart from one another by exactly one frame or a multiple of frames. The secondary maxima can result in the detection of (invalid) "shadow data transmission paths" 101s, which cannot be suppressed by the first two stages 501 and 502.

10

Since the side lobes of a particular sampling code have a defined relationship with the primary peak value 401a-401n, the third threshold value 103a can be determined from the amplitude of the position of the

15 strongest data transmission path and can be set with a variable Δ_{103c} in line with the formula below

$$S_{103c} = \text{Max } \{401a, \ldots, 401n\} \ / \ \Delta_{103c} \qquad (10)$$

20 The parameter Δ_{103c} depends on the settings of the PDP determination device N_{corr} and N_{avg} and can be derived in advance and stored in a table. As the result of this third stage, the filtering device 503 outputs a finger positioning signal 504 which outputs the detected data

25 transmission paths (described by a position and accumulated in the power over M periods). The detected data transmission paths are supplied to the processing device 308 described in figure 3 in the form of a finger position signal 307, so that corresponding

30 adjustments for the rake fingers and summation thereof can be performed.

To perform automatic data transmission path detection, the threshold values 103a, 103b and 103c are

35 automatically set and aligned with the corresponding noise environment. The setting for the first and second threshold values 103a and 103b can be derived on the basis of an estimation of a mean value μ_{pdp} and of a

variance σ^2_{pdp} or of a standard deviation σ_{pdp} in the noise samples pdp_{cst}. In this context, the mean value μ_{pdp}, the variance σ^2_{pdp} and the standard deviation σ_{pdp} are detected from a received signal strength which, as will be explained with reference to figure 6, is output from a received signal strength determination unit 606.

In the formulae below, this variable for the received signal strength is denoted by RSSI (Received Signal Strength Indicator).

$$S_{103a} = a_1 \cdot \mu_{pdp} + b_1 \sigma_{pdp} \qquad (11)$$
or
$$S_{103a} = a_1 \mu_{pdp} + b_2 \sigma^2_{pdp} \qquad (12)$$

The variables μ_{pdp}, σ_{pdp} and σ^2_{pdp} are determined from the signal RSSI in line with the equations below

$$RSSI = \frac{1}{N_{RSSI}} \sum_{n=0}^{N_{RSSI}} \left(r^2_{s(n)} + r^2_{Q(n)} \right) \qquad (13)$$

$$\sigma_{pdp} = \frac{RSSI}{N_{corr}\sqrt{N_{avg}}} \qquad (14)$$

$$\sigma^2_{pdp} = \frac{RSSI^2}{N^2_{corr} \cdot N_{avg}} \qquad (15)$$

$$\mu_{pdp} = \frac{RSSI}{N_{corr}} \qquad (16)$$

Since the variable RSSI can change over time, the threshold values need to be updated periodically. If a distribution of noise samples corresponds to a Gaussian distribution function, the false detection rate P_{502} can be controlled exactly by the first threshold value 103a

in line with equation (11). The second threshold value 103b can be chosen on the basis of the first threshold value 103a, in line with

5       $S_{103b} = c \cdot S_{103a}$ (17)

Further preferred exemplary embodiments of the present invention will be described below.

10   In the subsequent figures, a reference symbol 601 denotes a processor device which has a multipurpose processor in software. This multipurpose processor can be implemented, by way of example, in a digital signal processor or a microcontroller.
15

A reference symbol 602 distinguishes a matched hardware block which needs to be designed specifically for the corresponding exemplary embodiment. The matched hardware block 602 and the processor device 601 are
20   connected by means of a processor bus 603.

In line with the exemplary embodiment shown in figure 6, the matched hardware block 602a has a power delay profile determination unit 303, a peak value detection
25   device 501 and a received signal strength determination unit 606. In addition, the matched hardware block 602a can comprise a threshold value determination unit 605, which can also be provided in the form of a software module on the processor, however. The received signal
30   301 is supplied both to the power delay profile determination unit 303 and to the received signal strength determination unit 606.

From the received signal strength determination unit
35   606, an RSSI signal is derived in order to supply it to the peak value determination unit 605. To detect peak values in the peak value detection device 501, the first threshold value 103a is first determined in the

threshold value determination unit 605 and is supplied to the peak value detection device.

It will be pointed out that an optimized first
5 threshold value 103a can change for each power delay profile determination step, which means that it may be necessary to update this parameter for each individual determination operation in order to obtain an optimum operating response.
10

For these reasons, it is advantageous to set the first threshold value 103a on the basis of the RSSI signal, which has been derived on the basis of equation (14) above. The peak values 401a-401n detected using the set
15 first threshold value 103a are stored in an output buffer store (not shown) and are then supplied to the processor device 601 via the processor bus 603.

In the case of hardware calculation of the first
20 threshold value 103a, it is also necessary to supply the first threshold value to the processor device 601, since calculation of the second threshold value 103b is based on the first threshold value 103a, cf. equation (17) above.
25

The processor device 601a has a data transmission path profile unit 502a, a data transmission path detection unit 502b and a filtering device 503. As described above with reference to figure 5, in this way the
30 second and third threshold values 103b and 103c are used to produce a finger positioning signal 504 and to output it to a downstream processing device 308.

One advantage of the exemplary embodiment described
35 with reference to figure 6 is that implementing the first stage, i.e. peak value detection device 501, in the matched hardware block 602a significantly reduces the volume of data which need to be transferred from

the matched hardware block 602a to the processor device 601a via the processor bus.

Figure 7 shows a further preferred exemplary embodiment
5 of the present invention. A processor device 601b is connected to a matched hardware block 602b by means of processor bus 603. The matched hardware block 602b in the exemplary embodiment in figure 7 has, besides the power delay profile determination unit, a peak value
10 sorting unit, with the received signal 301 respectively being supplied to the power delay profile determination unit 303 first of all.

The output signal from the power delay profile
15 determination unit 303 is supplied to the peak value sorting unit 701, which provides sorting of the peak values 401a-401n in terms of a received signal power 107.

20 In the exemplary embodiment shown in figure 7, peak value detection is performed in a peak value detection device 501 provided in the processor device 601b. In the exemplary embodiment shown in figure 7, the first threshold value 103a now does not need to be provided
25 in advance, in contrast to the exemplary embodiment shown in figure 6, but rather is set by a threshold value setting unit 702. A permanently set number of detected peak values which are sorted in terms of their magnitude by the peak value sorting unit 701 ensures
30 that it is always the peak values 401a-401n with the highest received signal power 107 which are processed.

The first threshold value 103a, provided by the threshold value setting unit, is also supplied to the
35 data transmission path detection unit 502b, in which the second threshold value 103b is set on the basis of the first threshold value 103a. The remaining blocks in the processor device 601b correspond, in terms of their

manner of operation, to the blocks shown in figure 6 and are not described further at this point.

Figure 8 shows a third preferred exemplary embodiment
5   of the present invention. In figure 8, a matched hardware block 602c contains no function blocks other than the power delay profile determination unit 303. All other functions are performed in the processor device 601c in order to provide the correct finger
10   positioning signal 504.

The exemplary embodiment shown in figure 8 opens up the highest level of flexibility for a threshold value calculation, but requires a relatively large output
15   buffer store (not shown) for the matched hardware block 602c as a power delay profile determination unit 303.

Although the present invention has been described above with reference to preferred exemplary embodiments, it
20   is not limited thereto but rather can be modified in diverse ways.

The invention is also not limited to said application options.

List of reference symbols

In the figures, identical reference symbols denote components or steps which are the same or have the same function.

100	Data stream receiver
101, 101a- 101n	Data transmission path
101a	Direct data transmission path
101b, 101c	Indirect data transmission paths
101s	Shadow transmission path
102	Data stream
103a	First threshold value
103b	Second threshold value
103c	Third threshold value
104	Noise signal
105	Signal-to-noise ratio
106	Correlation delay (k)
107	Received signal power
108	Power
109	First reception device
111	Probability distribution
200	Data stream transmitter
201	First antenna, transmission device
202	Second antenna, transmission device
203	Data frame
203a... 203i... 203N	Data frames
204a... 204i... 204n	Slots
205	First symbols
206	Second symbols
300,	Power delay profile

PDP

301	First received signal
303	Power delay profile determination unit
304	Data transmission path detection unit
305	Setting device
306, 504	Data transmission path position signal
307	Finger position signal
308	Processing device
309a-309N	Rake fingers
310	Summation unit
311	Output signal
401, 401a-401n	Peak value
402, 402a-402n	Noise peak values
500	Power delay profile signal
501	Peak value detection device
502	Data transmission path profile determination device
502a	Data transmission path profile unit
502b	Data transmission path detection unit
503	Filtering device
601a-601c	Processor device
602a-602c	Matched hardware block
603	Processor bus
604	Hardware block as part of 602a or processor device (part of 601a)
605	Threshold value determination unit
606	Received signal strength determination unit
701	Peak value sorting unit
702	Threshold value setting unit
P	Probability

S2941

S   Threshold value